# Internal Structure of Earth and Plate Tectonics

## **Chapter 2**

# **Learning Objectives**

## Understand the basic Internal Structure and Processes of the Earth

## Know the basic ideas behind and evidence for the Theory of Plate Tectonics

## Understand the Mechanisms of Plate Tectonics

## Understand the Relationship of Plate Tectonics to Natural Hazards

# **The Internal Structure of Earth**

## The Earth is a **complex dynamic planet**

### By **composition and density** (heavy or light)

### By **physical properties** (solid or liquid, weak or strong)

## The Earth has a **rigid outer shell, a solid center, and a thick layer of liquid that moves around as a result of dynamic internal processes**

## The Internal Processes are **responsible for the effecting the surface of the earth**

# **The Earth is layered and dynamic**

* Composition of the Earth’s Interior
* Crust with a variable thickness
* Mantle surrounding the outer core
* Liquid Outer Core
* Solid Inner Core
* **The Inner Core**

### **Solid and very dense mass having a radius of 808 miles**

## Both the inner and outer core are made of **iron/nickel or iron/silicate.**

## Makes up **15% of the Earth’s volume and 32% of its mass**

## The Earth’s **magnetic field is generated primarily in the outer core**

## **Magnetic field changes over time from the North Pole to South Pole**

## **The Outer Core**

### Molten and extending to a **depth of about 1243 miles**

### Composition is similar to the inner core

## Above the Inner Core is the **Mantle (1864 miles)** where there is a change in mineral composition

### The **Mantle** iswhere convection takes place moving the plates

### Between the **Mantle and the crust is the Mohorovicic discontinuity (or Moho)**

## The **Crust** is the outermost hard shell, consists of a broad mixture of rock types

## This is called the **Lithosphere (from the Greek word for rock)**

### Average thickness averages 3 miles, between continental and ocean crusts

### The continents’ crust averages more than 5 times that of the oceans crust

# **How Do We Know About the Internal Structure of Earth**

## **We have learned about Earth through the study of Earthquakes**

### This study is called **Seismology.** Though this science,we have learn about the structure of the Earth

### **Seismology is the study of earthquakes** and the passage if **seismic waves through the earth**

### These waves are called **P waves and S waves**

#### These waves travel through the earth at different rates

#### It is been through the **study of the travel of these waves that Seismologists have been able to describe the center of the earth.**

## These studies have been able to determine

### Where **magma is generated in the asthenosphere**

### The **existence of slabs of lithosphere that have apparently sunk deep in the mantle**

### The **extreme variability of lithospheric thickness, reflecting its age and history**

# **Plate Tectonics**

## **The term *tectonics* refers to the large-scale geologic processes that deform the Earth’s lithosphere**

## **Movement of the lithospheric plates**

### What is Plate Tectonics???

### **Processes associated with creation, movement, and destruction of the *lithospheric plates* collectively are called plate tectonics**

## **Locations of earthquakes and volcanoes define Plate Boundaries**

### Plates may include both a continent and part of an ocean basin or an ocean region alone

### Some plates are very large, some are very small, are relative to their location

### Most **earthquakes and volcanoes** are associated with the **interactions of the plate boundaries, mostly defining where they are**

### Over the geologic time, **plates are formed and destroyed, cycling materials from the interior of the Earth to the surface and back again**

## **This is the Tectonic Cycle**

## **Seafloor Spreading is the Mechanism for Plate Tectonics**

### As **plates move over the asthenosphere, they carry the continents embedded within them**

#### This idea was first suggested by a German scientist Alfred Wegener in 1915.

#### He suggested the **theory** of ***Continental Drift,*** based on the **congruity of the shapes of the continents** across the Atlantic Ocean

#### He also looked at shapes of both South America and Africa and theorized that the shapes of the **two continents fit as if they once were one**

#### In the late 1960’s this theory was finally accepted when **seafloor spreading** was discovered

# **Seafloor Spreading is the Mechanism for Plate Tectonics**

## **Mid-oceanic Ridges or Spreading Centers** are continuously adding to the edges of the lithosphere

## The other edges of the lithospheric edges are being destroyed at **Subduction Zones** around the Earth

## Continents do not move ***through*** oceanic crust; they are **carried along with it with the movement of the plates**

## The **creation of lithosphere at the Ridges is balanced** by the **consumption of the lithosphere at Subduction Zones**

## **The Earth remains constant, neither growing nor shrinking**

# **Types of Plate Boundaries**

## **There are three types of Plate Boundaries**

## **Divergent Boundaries**

### Where neighboring plates are pulling apart

### New Lithosphere is released here expanding the ocean floor

### These are ocean ridges or continental riffs

#### Examples are the Atlantic Ocean Ridge or the Red Sea Riff

## **Convergent Boundaries**

### These are where **plates merge together**

### There are **three basic convergent boundaries**

#### **Ocean-Continental Boundaries** – Ocean plate sub-duct under the Continental Crust

##### Creates –**trenches, volcanoes** – Chilean Mountains and Trench

#### **Ocean-Ocean Boundaries** – Older Ocean plate sub-duct under the newer Ocean plate

##### Creates – **volcanic islands, submarine trenches-** Japan and Mariana Trench

#### **Continental-Continental Boundaries** – no subduction happens, uplift occurs

##### Creates- **mountain ranges**- Himalayan Mountains

# **Transform Boundaries**

## A **Transform Fault** or **Strike Slip Fault**

### Where the **edges of two plates slide past each other**

### Contains a **series of riffs (spreading) along the fault**

#### Best known- **San Andreas Fault in California**

#### Causes many earthquakes

#### San Francisco on its way to the Gulf of Alaska

#### Also found in **Turkey**

# **Rates of Plate Motion**

## **Plate Motion is a Fast Geologic Process (comparatively)**

## **Plates move a few centimeters per year (about as fast as your fingernails grow)**

## **This can cause some features, streams or rocks to be displaced over time where the feature crosses the fault**

# **Detailed Look at Seafloor Spreading**

## **By the 1950’s the theory of Continental Drift accepted**

### Supported by depth soundings

### Found seamounts/ridges or trenches

## **Seafloor spreading**

### **1960’s new theory- by Harry Hess and Robert Dietz**

### **Mechanism for continental drift,** mid ocean ridges form from rising mantle creating ridges, spreading the ocean floor

### Verified by the **Paleomagnetism—reversal of pole magnetism**

# **Sea Floor Spreading**

## The **Validity of Seafloor Spreading from three sources**:

### Identification and mapping of the oceanic ridges

### Dating of volcanic rocks on the floor of the ocean

### Understanding and mapping the paleomagnetic history of the ocean basins

* Paleomagnetism
  + Study of Paleomagnetism history helps to understand sea floor spreading and plate tectonics
  + Because of the convection processes within the earth, the earth has experienced the periodic magnetic reversals
  + This produces magnetic “stripes” in the iron bearing minerals found on the earth’s floor
* **New crust is formed and returned to the mantle every 200 million years**

# **Hot Spots**

### Spots of volcanic activity caused by a thin Earth’s crust allowing the magma to move to the surface

### These are called **Hot Spots or Mantle Plumes**

### Hawaii and Yellowstone fall on such Hot Spots

### As the plate moves across the Pacific Hot Spot, a **trail of islands are left, creating the Hawaiian Island archipelago**

### These islands are called ***seamounts***

### **Hot Spots help to explain volcanic activity in the middle of plates and help to distinguish the direction of the plate’s movement**

# **Pangaea and Present Continents**

## **Summary of the time line from Pangaea to the Present**

### **450 million years** – **5 continents**- merged together to form **Pangaea**

### **Next 200 million years; one continent**

### **200 million years** – **Pangaea starts to break up**– **Laurasia & Gondwanaland**- then to even smaller pieces

### **135 million years** -- North and South Atlantic Oceans begin to open, separating South America and Africa, Mediterranean Sea began to close as Africa began to rotate northward toward Asia

### **65 million years --**North and South Atlantic Oceans joined; South America was new Continent and moving westward, Andes growing, as South America overrides the Pacific Plate. Rockies were rising but not the Sierras

# **Assembly & Breakup of Pangaea**

## **“Today”** South America connected to North America

### North America separated from Europe

### Europe, Australia has split from Antarctica

### India collided with Eurasia-thrusting up the Himalayas

### All continents are still in motion except for Antarctica

### Africa is splitting along Great Rift Valley rotating counterclockwise

# **Future of the Continents**

## **50 million years from now**

### Australia will straddle the equator is huge tropical island

### Africa may pinch the Mediterranean shut

### East Africa becomes large island like Madagascar

### The Atlantic will widen while the Pacific will shrink

### Southern California, now a chilly island will pass San Francisco heading for its ultimate destination in the Aleutian Trench of the Gulf of Alaska

# **Understanding Plate Tectonics Solves Long-Standing Geologic Problems**

## Understanding Plate Tectonics theory helped to clear up two geological mysteries:

### How did **fossils of the same animals and plants** end up in both **South America and Africa**?

### Evidence of **ancient glaciation on several continents with inferred directions of ice flow were the same as if there was only one continent**?

# **How Plate Tectonics Works: Putting it Together**

## **Driving Mechanisms that move the plates**

### **This could be call a “push me pull me” method**

#### The mid-ocean ridge pushes new magma up creating new ocean floor, moving the old crust outward

#### The old crust moves outward from the mid-ocean ridge

#### As this happens, the new crust pushes the lighter continental plates over the asthenosphere

#### The continental plate moves until it hits another plate

#### Depending on the kind of plate, there will be a subduction or a collision, with either volcanoes or trenches created or huge mountain ranges built

#### **Convection in the mantle and asthenosphere guarantee this process will continue**

# **Plate Tectonics and Hazards**

## **Plate Tectonics Affect Us All**

### The ***Linkages* of plate tectonics to hazards is obvious**

### Where **plate boundaries** are located, volcanoes and earthquakes can occur

### Conclusions from these occurrences are:

#### **Divergent boundaries can be associated with volcanoes** **and earthquakes**

##### Example: Iceland

#### **Transform boundaries – earthquake hazards are intensified, and where mountains are found landslides and flooding may be experienced**

#### **Convergence Boundaries cause many hazards,**

##### Mountainous areas have landslides and flooding

##### Volcanoes and earthquakes can be expected

## **Plate Tectonics are associated with the natural hazards found around the world**

## **Man only makes the hazards into disasters and catastrophes**